(12) UK Patent Application (19) GB (11) 2 326 623 (13) A

(43) Date of A Publication 30.12.1998

(21) Application No 9713725.1

(22) Date of Filing 27.06.1997

(71) Applicant(s)
AlliedSignal Limited
(Incorporated in the United Kingdom)
Douglas Road, Kingswood, BRISTOL, Avon, BS15 2NL,
United Kingdom

(72) Inventor(s)
Alan George Smithson

(74) Agent and/or Address for Service
W P Thompson & Co
Celcon House, 289-293 High Holborn, LONDON,
WC1V 7HU, United Kingdom

(51) INT CL[6]
B60R 22/46

(52) UK CL (Edition P)
B7B BVRP

(56) Documents Cited
GB 2306294 A GB 2292304 A WO 97/13661 A1
US 4301977 A

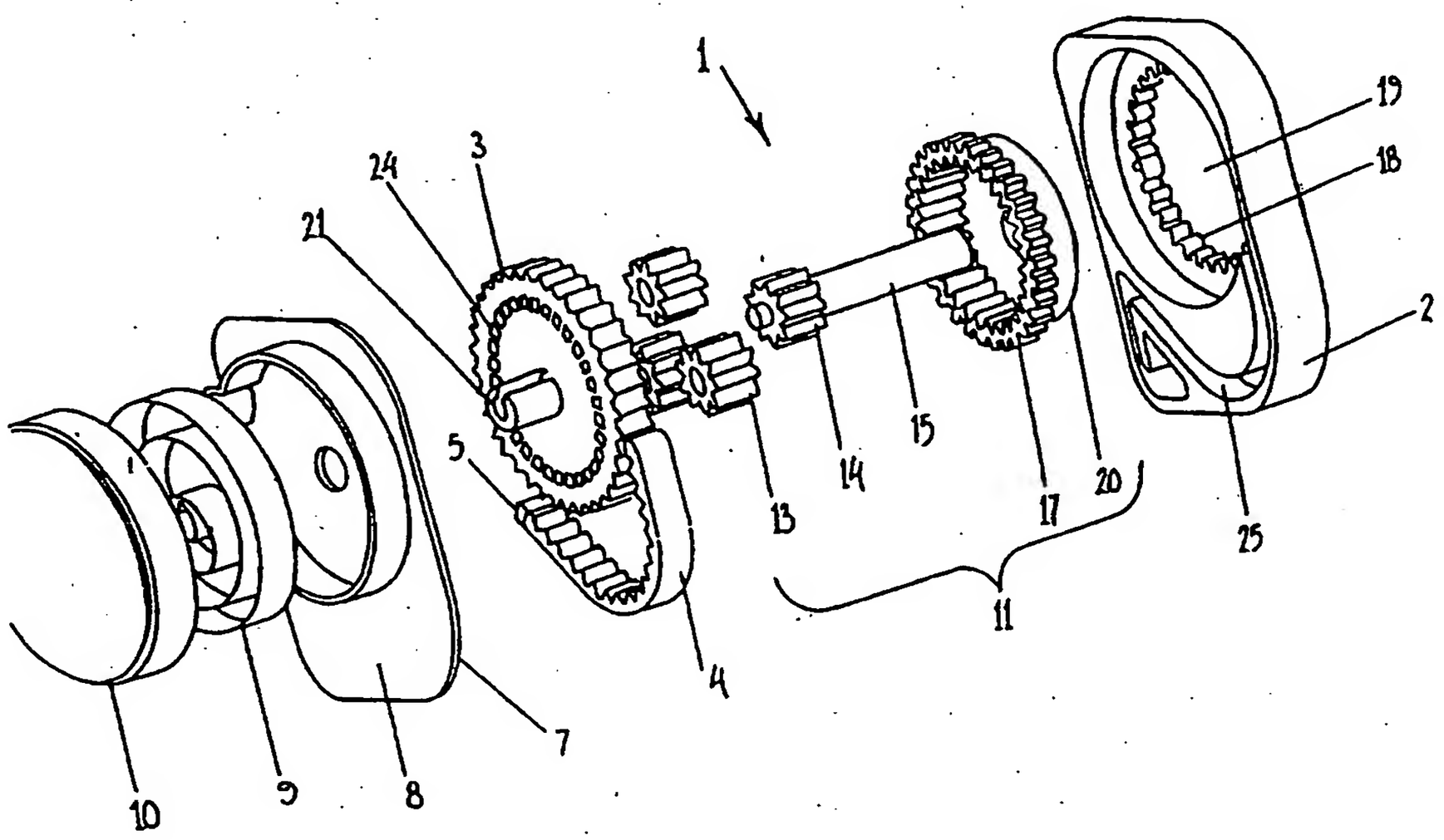
(58) Field of Search
UK CL (Edition O) A3V
INT CL[6] B60R 22/44 22/46
Online: WPI

D2

(54) Abstract Title
Pretensioner and comfort device driven by two ratio epicyclic gear.

(57) The pretensioner comprises a housing 2, 7, a retraction spring 9, a drive chain 4 and an epicyclic gear 11. The spring turns the drive wheel/planet carrier 3 causing stubs 12 to rotate. The stub mounted planet wheels 13 engage the sun wheel 14 and internally toothed annulus 16 causing shaft 15 to rotate, thereby driving the seatbelt spool. Annulus 16 is axially movable 23 such that external teeth 17 engage either drive wheel 3 or casing teeth 18 lock to it relative to the drive wheel or the casing, thereby determining the gear ratio. Emergency pretension is applied by chain 4, driven by gas pressure on piston 5 engaging and turning drive wheel 3. The gear ratio is dictated by sensors indicating factors like passenger weight or position or by non emergency belt position.

FIGURE 2



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2 326 623 A

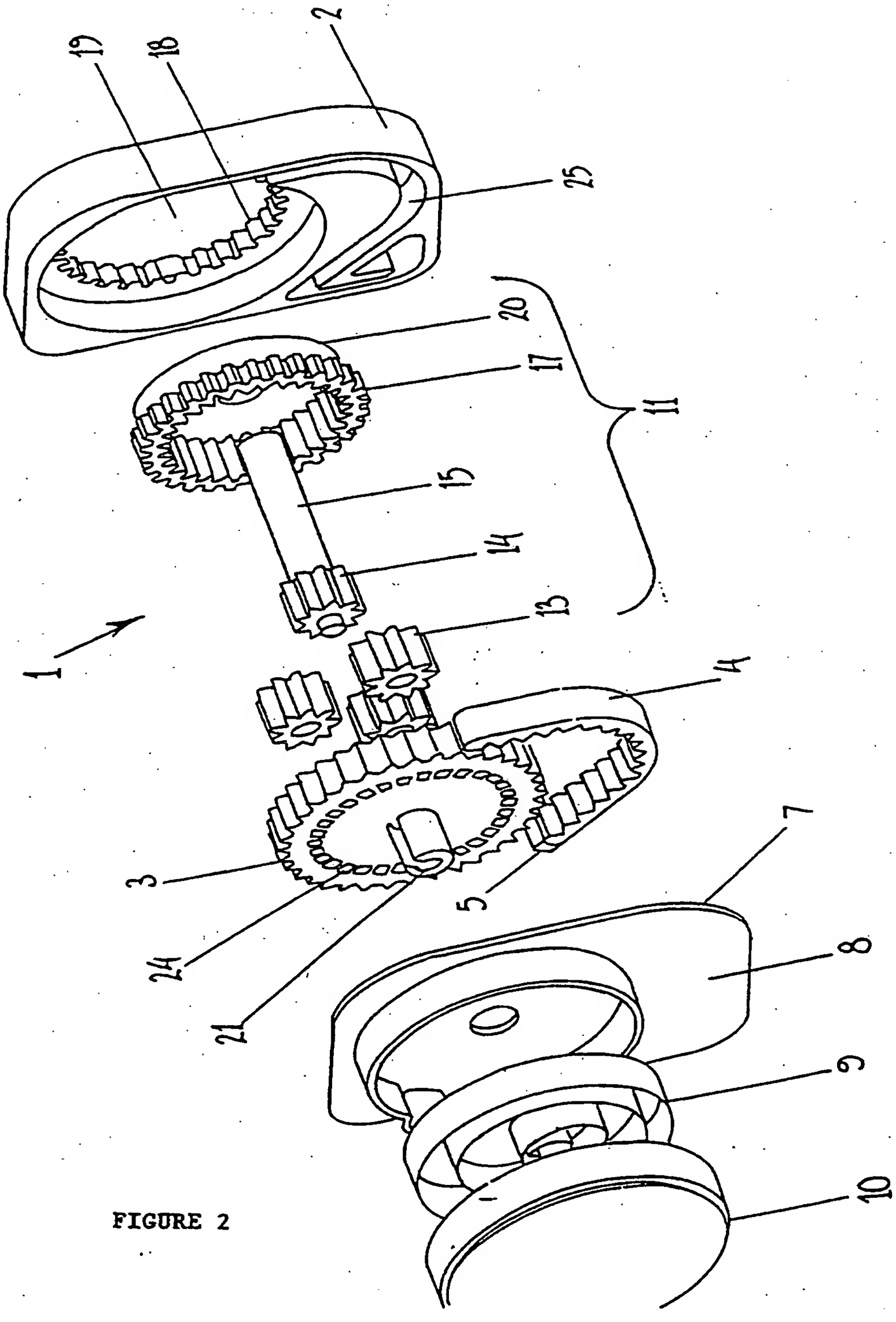


FIGURE 2

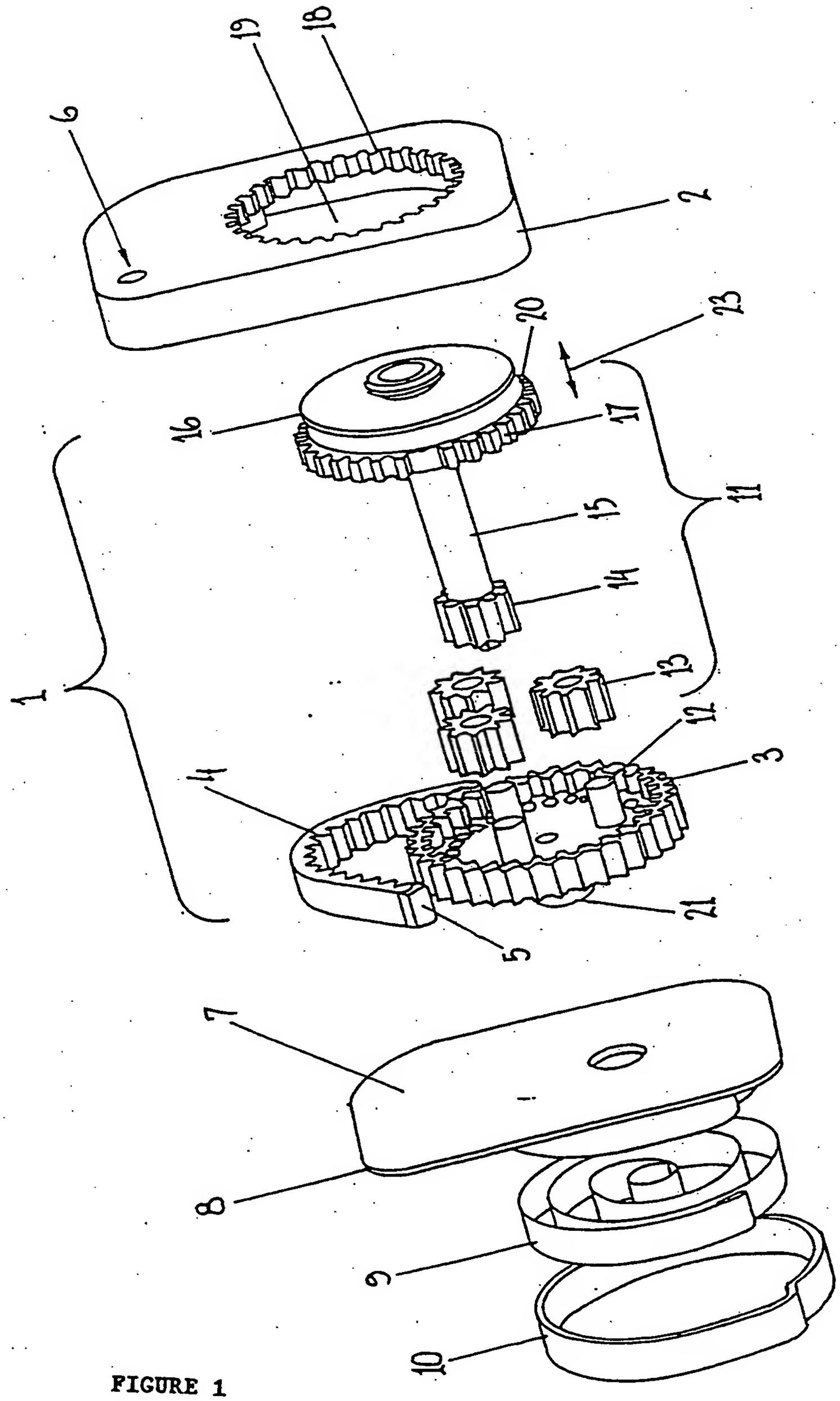


FIGURE 1

FIGURE 3

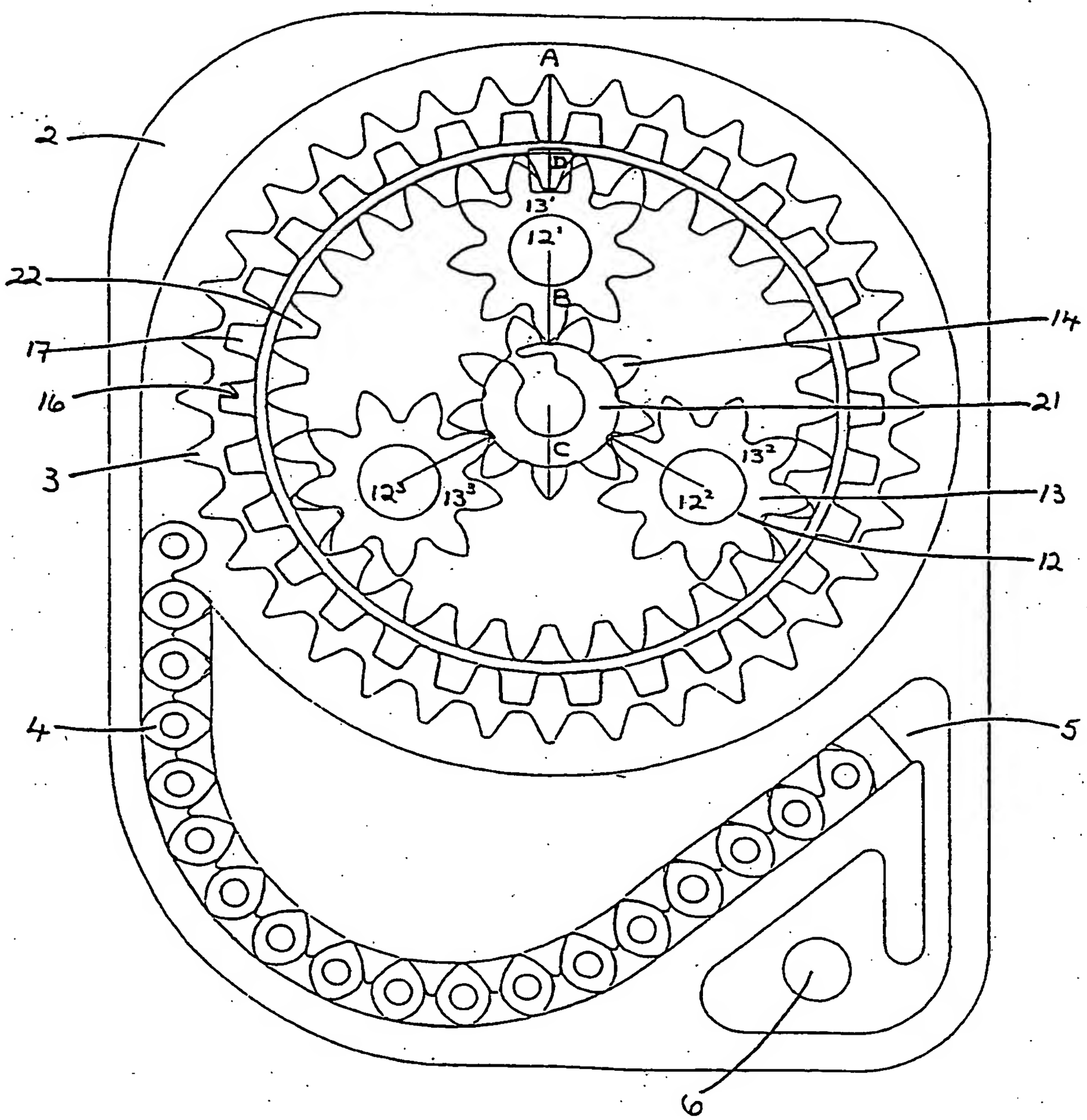


FIGURE 4

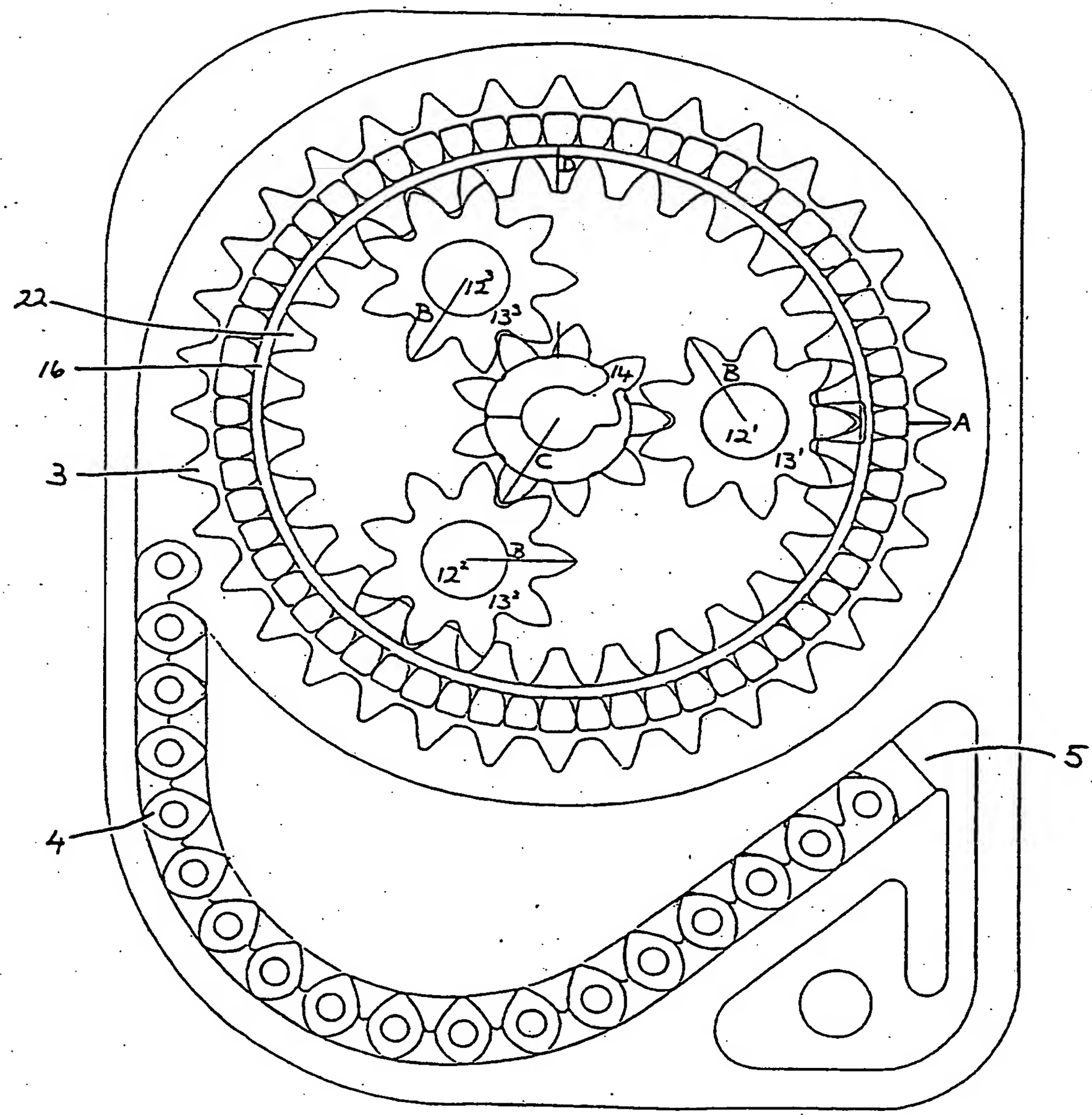


FIGURE 5

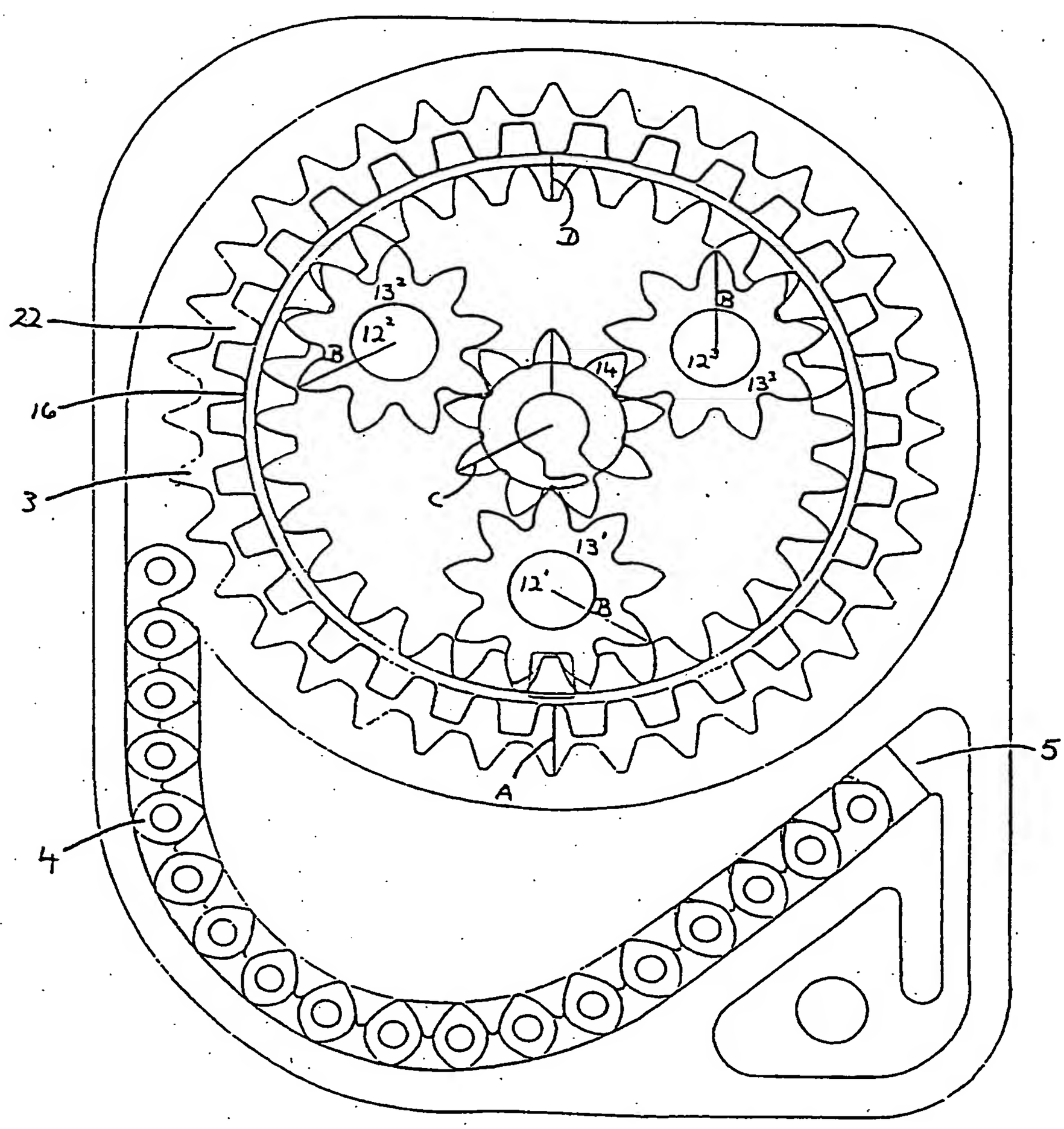


FIGURE 6

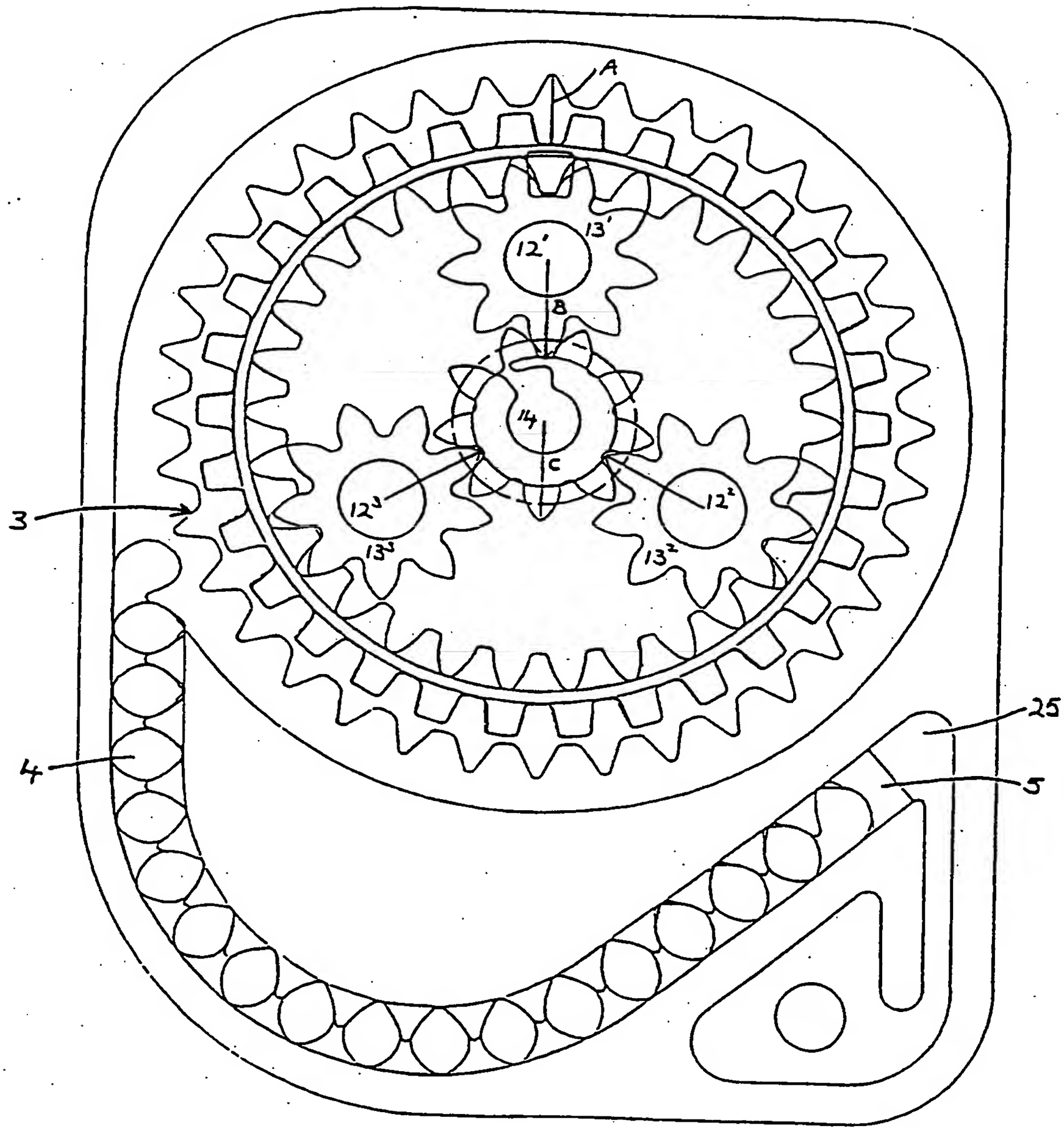


FIGURE 7

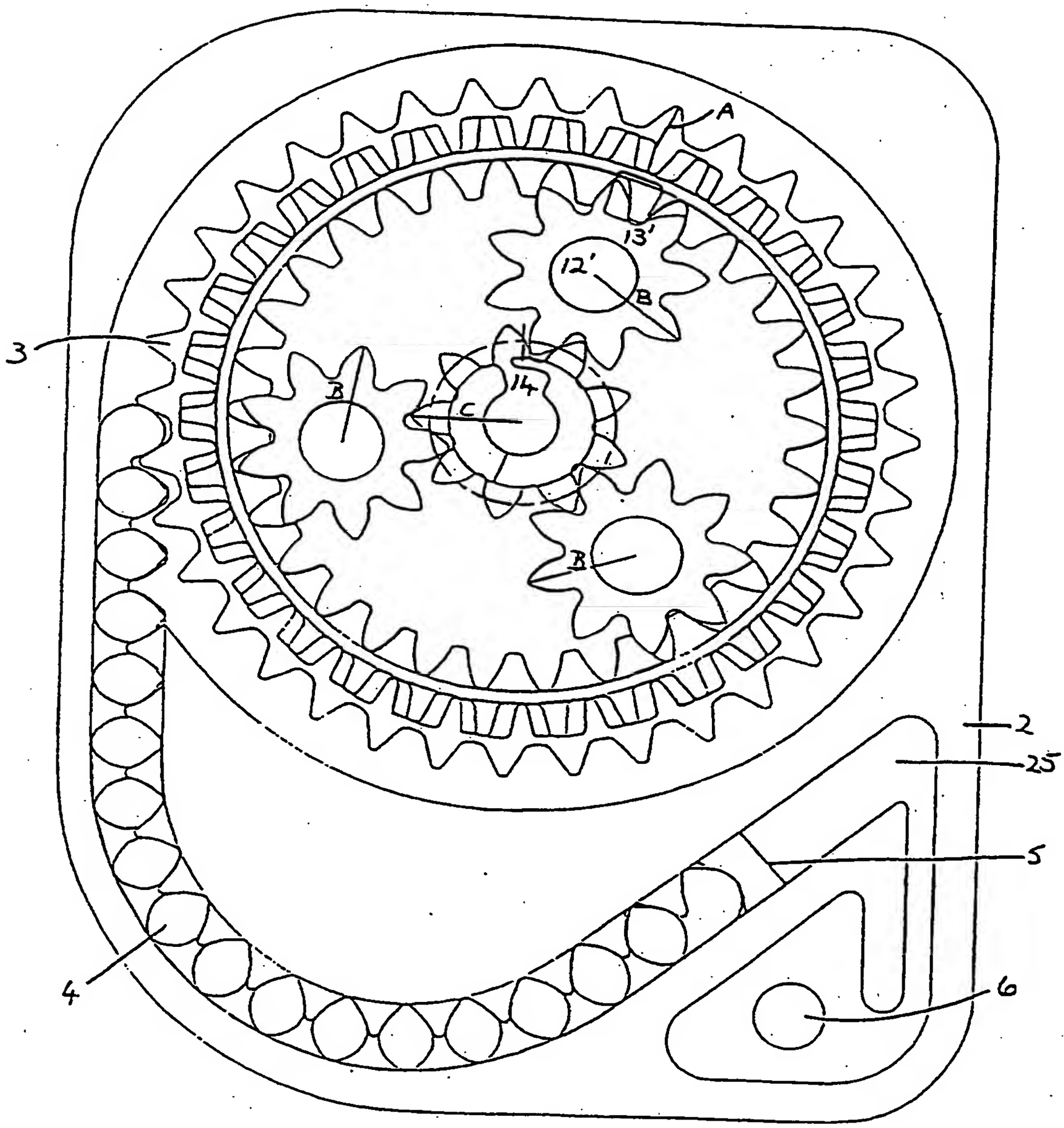


FIGURE 8

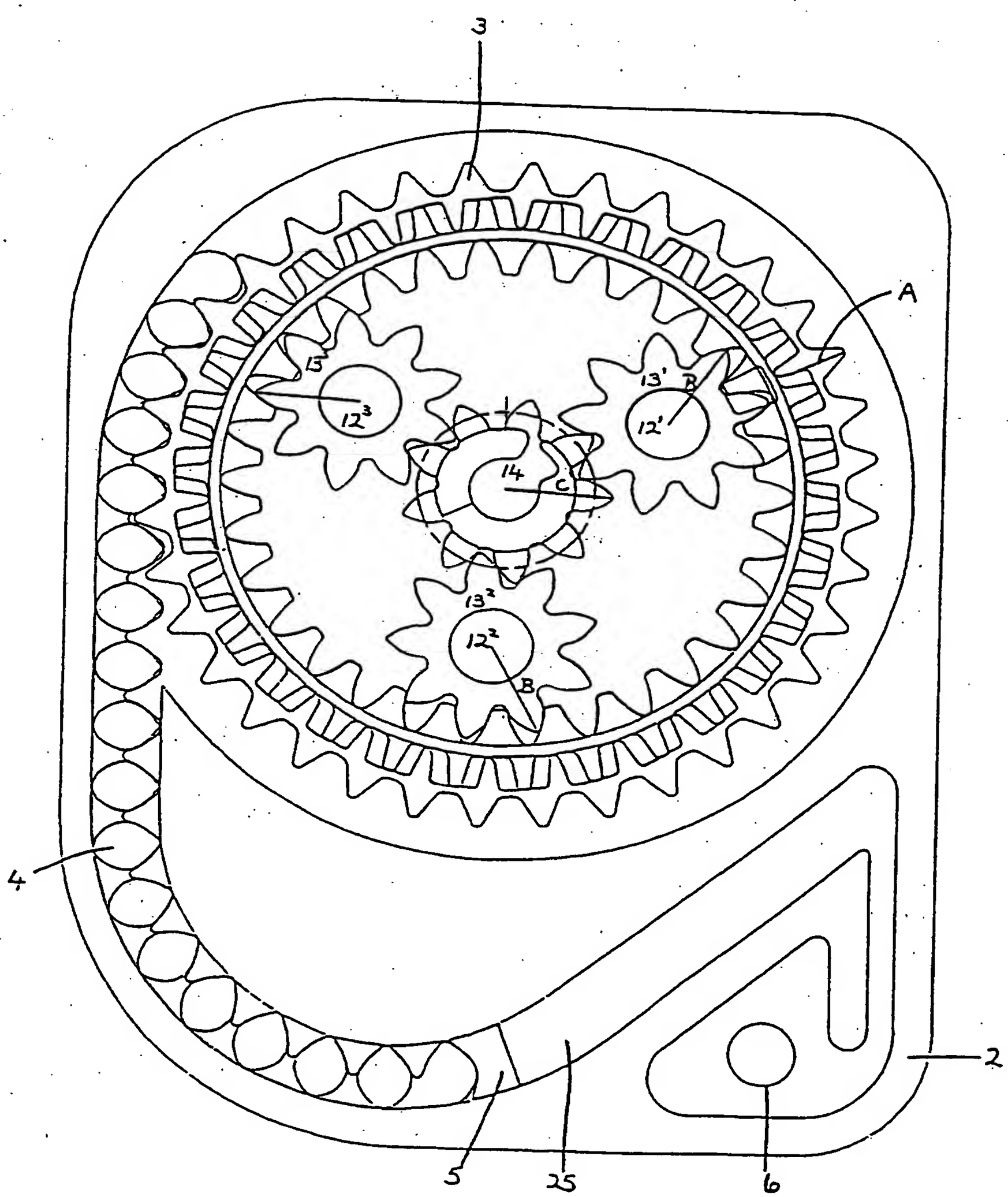


FIGURE 9

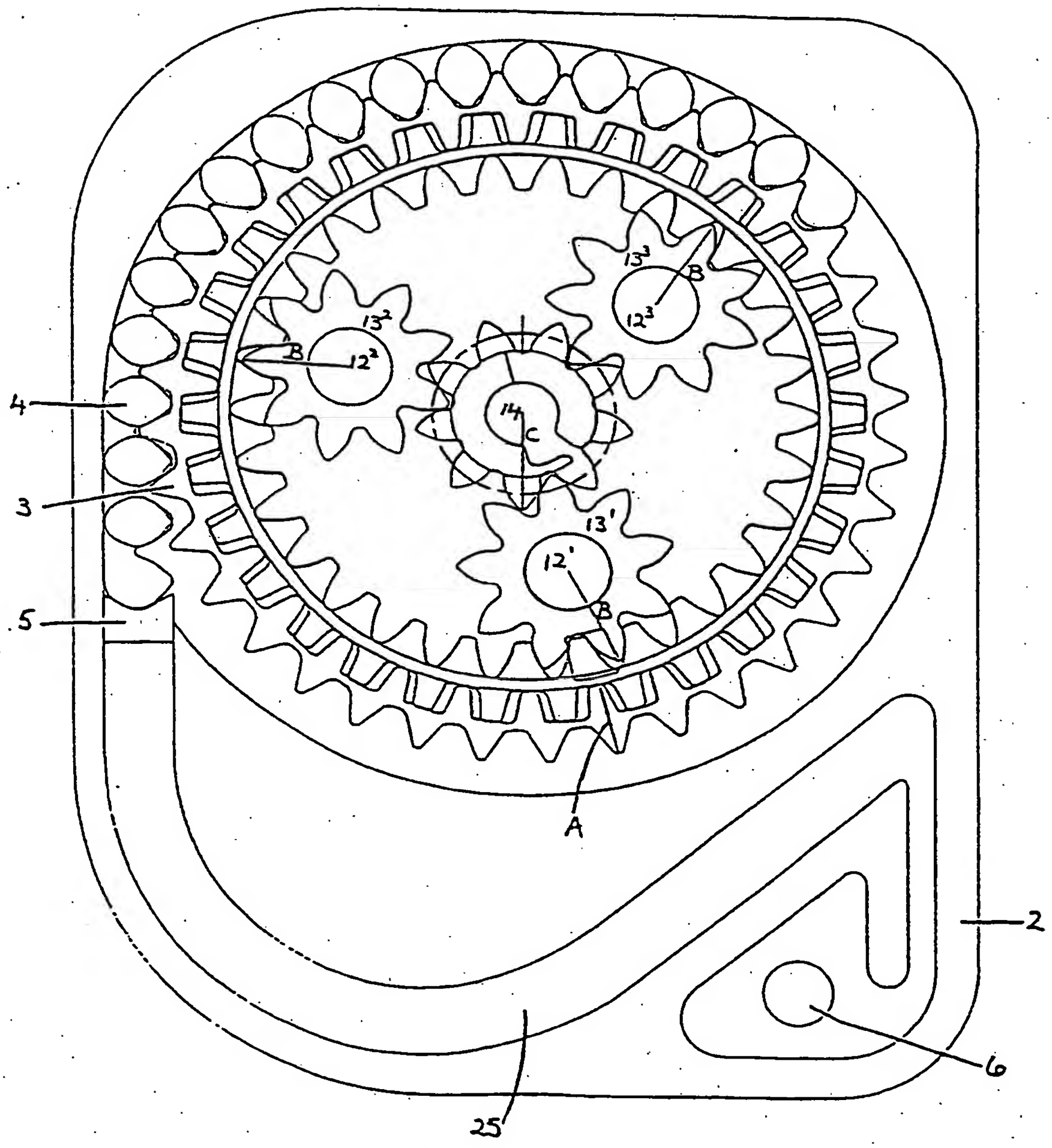
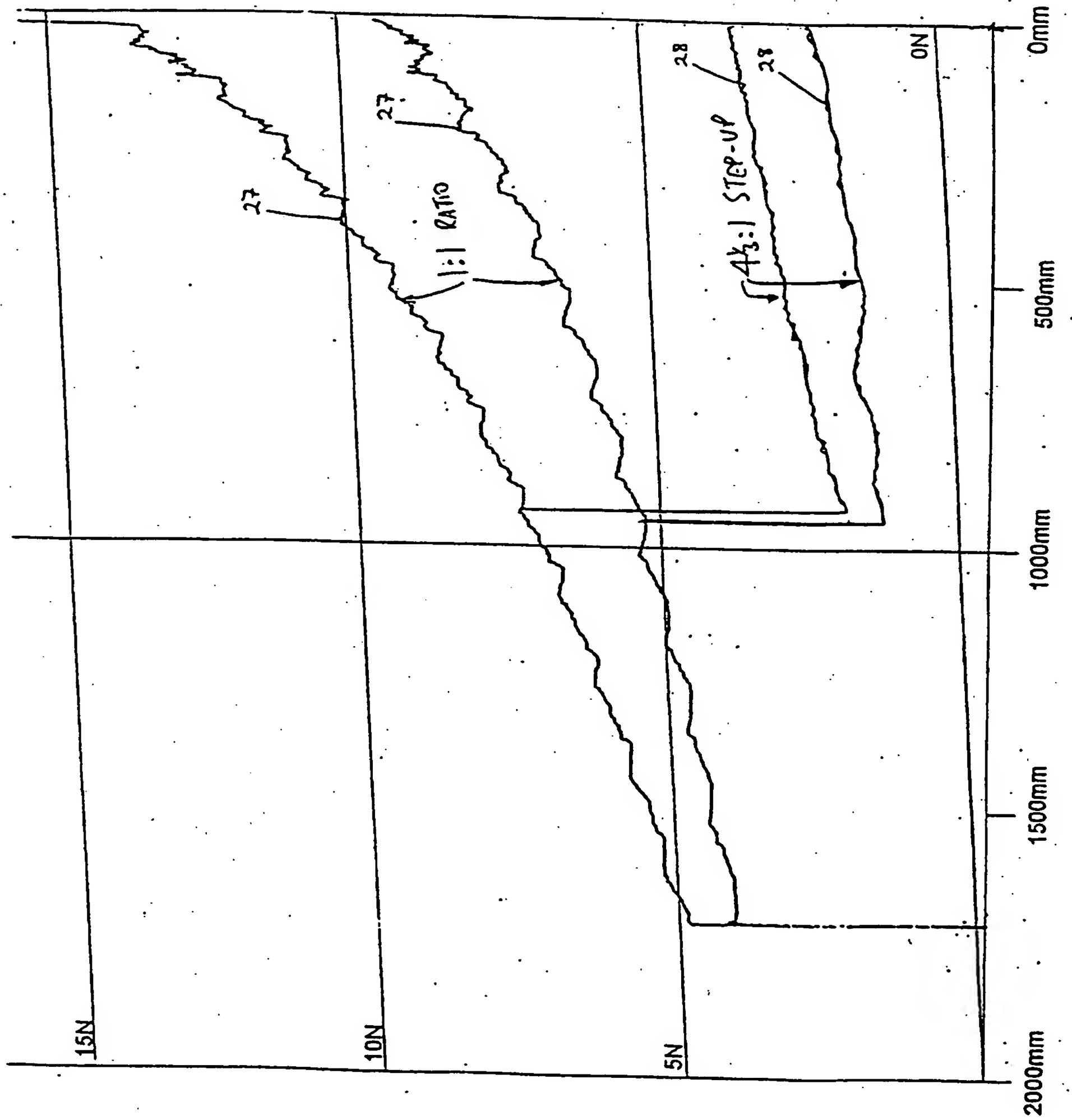


FIGURE 10


27
27
1:1 RATIO
28
28
4½:1 STEP-UP
ON
0mm
500mm
1000mm
1500mm
2000mm
15N
10N
5N

PRETENSIONER

DESCRIPTION

The present invention relates to a pretensioner, in particular to a compact pretensioner for a retractor in a vehicle safety restraint belt system, especially to a pretensioner combined with a comfort device.

Pretensioners for vehicle safety restraint systems have been known for sometime. They act, on sensing a crash condition, to take up slack in the seat belt so as to more securely restrain the vehicle occupant. This may be done by pulling back the buckle mounting or alternatively, as in the present invention, by rapidly rewinding the seat belt webbing onto the inertial retractor.

Known pretensioners tend to be bulky and difficult to fit in a vehicle, particularly in a position close to the retractor, without been unsightly and spoiling the interior decor of the vehicle. In addition known pretensioners require a high power to operate them fast and efficiently enough and to overcome the inherent friction in such systems. Problems have also been encountered with wear. A much lighter device which operates as a lower speed and thus requires a lower force, but still retracts the same amount of seat belt webbing speedily enough, is highly desirable.

A known retractor pretensioner with an epicyclic gearing system is described in EP 0 628 454 A wherein a rotary paddle type pretensioner is connected to the spool by

planetary gears.

It is an object of the present invention to provide an improved pretensioner, and an improved retractor.

In addition it is desired to make a light compact pretensioner.

The present invention is also concerned with comfort devices in retractors, which in general relieve some tension on the seat belt webbing so as to make it more comfortable for the vehicle occupant evidently without prejudicing the occupant's safety.

According to one aspect of the present invention there is provided a pretensioner for rapidly rewinding seat belt webbing onto a spool of a vehicle safety restraint seat belt retractor, the pretensioner comprising

drive means for rapidly rewinding the retractor spool in response to predetermined conditions indicative of a crash,

a gear system linking the drive means to the retractor spool, the gear system being operable in at least two different ratios, and

switching means for changing the gear system ratio.

The gear ratio switching means has considerable advantages since it allows the amount of webbing rewound in a pretensioning operation to be predetermined, for example for different impact conditions, different occupant

position, weight or size conditions.

According to a preferred embodiment the pretensioner drive means comprises

a drive wheel with radially extending peripheral teeth,

a flexible elongate member with apertures regularly spaced along its length, the spacing corresponding to the spacing of the teeth on the drive wheel, and

means for driving the flexible member, in response to a pretensioning signal, generally tangentially to the drive wheel to engage the teeth and to rotate the drive wheel.

The flexible chain member may be a chain and it may have one end formed as a piston, arranged in close proximity to a gas generator which, under pretensioning conditions, applies the force needed to drive the chain along.

The gear system advantageously comprises epicyclic planetary gears, with a ratio switchable between 1:1 and at least 1:3, preferably 1:4, although any range of values could be chosen.

This can be done by an annulus gear interposed between the drive wheel and the planetary gears, movable between a first position in which it is prevented from rotating giving the 1:1 ratio and a second position in which it rotates with the drive wheel, and steps the gears up to a 1:4 ratio.

There may be one or more sensors for detecting a predetermined condition of a vehicle occupant for example, out of position or above average weight.. The switching means can then be controlled accordingly and determine the most appropriate ratio of the gear system for the situation.

According to a second aspect of the invention there is provided a retractor for a vehicle safety restraint system comprising a rotatable spool for storing safety belt webbing, a rewind spring for biasing the spool in a webbing rewind direction and a pretensioner according to the first aspect.

This retractor preferably further comprises a comfort device for reducing the tension in the safety belt exerted by the retractor rewind spring, between predetermined extensions of the seat belt webbing.

In known fashion the comfort device preferably comprises epicyclic gears, but in inventive fashion these epicyclic gears are the same ones as those linking the pretensioner to the spool. This has considerable advantages in saving valuable space in the retractor pretensioner arrangement, and thus also in reducing production costs.

For a better understanding of the present invention and to show how the same may be carried into effect reference will now be made to the accompanying drawings in which;

Figure 1 is an exploded perspective view obliquely from one side of a retractor according to one

embodiment of the invention.

Figure 2 is an exploded view obliquely from the other side of the retractor of Figure 1.

Figures 3, 4 and 5 are cross-sectional views illustrating in sequence the operation of a comfort device forming part of the invention shown in Figures 1 and 2.

Figures 6 to 9 are cross-sectional views showing the sequence of operation of the pretensioner embodied in Figures and 2.

Figure 10 is a graph of force against retraction distance for the pretensioner of the present invention.

In Figure 1 the combined pretensioner and comfort device is indicated generally at 1. The pretensioner comprises a housing 2, a pretensioning toothed drive wheel 3 and a driving chain 4 of which one end forms a piston 5. The housing 2 has a gas inlet 6 to allow for the ingress of gas to push the piston 5 and thus the chain 4 past the toothed drive wheel 3, to drive it round in a pretensioning belt winding direction. The other side of the pretensioner/comfort device 1 is delimited by a face 7 of the retraction spring housing 8. The retraction spring housing 8 is closed by spring cover 10 on the outer side of the retractor. The retraction spring 9 is connected at its inner end to drive wheel 3 via slot 21 and operates in a

well known manner on the retractor spool (not shown) so as to keep the spool biased in a belt rewinding direction. The retraction spring 9 is in the form of a clock spring.

Drive wheel 3 is connected to the spool (not shown) by an epicyclic gearing system 11. One side surface of the drive wheel 3 has three axially protruding tabs 12. On each of these tabs 12 is mounted a toothed planet gear 13 and these three planet gears 13 surround and engage a sun gear 14 fixed on the output shaft 15 which is connected to the retractor spool (not shown). The planet gears 13 also engage the inside teeth 22 of an annulus gear 16. The operation of such epicyclic gears is well known to engineers.

The annulus gear 16 has two coaxial portions on its outer circumference: a toothed portion 17 and a non-toothed portion 20. The gear 16 is axially displaceable, specifically between two positions as indicated by arrow 23 in Figure 2. When it is in the right hand position (as seen in Figure 2) the radially extending teeth on portion 17 of gear 16 engage corresponding inwardly pointing teeth 18 around the circumference of the hole 19 of the housing 2 and rotation of the annulus gear 16 is prevented.

Movement of the drive wheel 3 moves the centres of the planet gears via tabs 12, causing them to turn about their own centres due to their engagement with the stationary annulus gear. They thus cause rotation of the sun gear 14 and consequently the spool output shaft 15 at a rate dependent on the ratio of the teeth spacing and is well

known to one skilled in the art. In the particular example illustrated the gear ratio is 4.33 to 1 and hence a single turn of the drive wheel cases 4.33 turns of the spool. This also has the effect of reducing the force level needed to turn the spool to about 23% of the level without the step-up gearing engaged. This is the so-called comfort zone since with this stepped-up ratio, the safety belt is more comfortable to wear; the effect of the rewind spring 9 is less significantly felt by the passenger since its force is reduced to about 23% since each turn of the spool in paying out webbing only tightens the spring by about 23% $\left(\frac{1}{4.33}\right)$ of a turn.

The full operation of the comfort device is described below in reference to Figures 3 to 5.

When the gear 16 is in the left hand position of Figure 2 then the teeth on the portion 17 of gear 16 engage inner teeth on the drive wheel 3 so that the two turn together. The non-toothed portion 20 of annulus gear 16 is relatively smooth and in this position when this non-toothed portion 20 is in line with the hole 19 and the annulus gear turns quite freely. The inner teeth 22 on annulus gear 16 still engage the planet gears but now the planet gears are contained against individual rotation about their axes; they all move round with the drive wheel 3. Thus they turn sun gear 14 at the same rate as the drive wheel 3, i.e. the gear ratio is 1:1.

In this position the comfort device is not operative;

the customer feels more restraining force from the retractor spring 9.

Thus the gear ratio can be switched by axial translation of the annulus gear 16. Various methods are envisaged for this axial translation in order to effect the switching, and a person skilled in the art would see many alternatives in this respect without inventive input.

Switching to a high gear ratio is also useful in pretensioning operations.

With the 1:1 transmission ratio, i.e. with the annulus gear 16 engaged with the drive wheel 3, operation of the pretensioner, by movement of the chain 4 across the drive wheel 3 causes the drive wheel 3 to make only about a half turn and the output shaft would likewise turn only about a half turn.

However with the step-up ratio, i.e. when the annulus gear is engaged with the housing 2 when the chain 4 moves past the drive wheel 3 it turns the drive wheel about a half turn, but interaction of the planet and sun gears, causes the output shaft and thus the spool to turn several full rotations (specifically two rotations in this example), the chain 4 will give two full turns of the output shaft for about 80mm movement of the chain 4. The force level is reduced to about 23% of the level which applies at the 1:1 ratio.

The full operation of the pretensioner is described in

more detail in the sequence diagrams of Figures 6 to 9.

Another feature shown in Figures 1 and 2 is a load limiting capability built into the drive wheel 3. This is illustrated at the shear section 24. If a particularly torque is applied to the drive wheel, this shear section which comprises an annulus of perforations, will break and allow free rotation of the output shaft and thus the spool. This is particularly important after a pretensioning operation has occurred, since the pretensioner may still have residual pressure and thus be holding the drive wheel against back rotation. In that case, the seat belt will be fixed in the retracted position and it may be difficult to release the occupant and certainly impossible to use the seat belt again or to allow the use of an integral load limiter in the retractor. Fracturing at the shear section of the drive wheel de-couples the pretensioner from the output shaft and allows rotation again. The retraction spring 9 is still connected to the spool via the hub 21 on the centre portion of the drive wheel 3.

The shear section of the drive wheel is designed to fracture at a torque higher than that exerted by the pretensioner in the step-up ratio but below that required for load limiting and will therefore allow load limiting in the step-up ratio. This shear section 24 is designed not to fail if pretensioning is conducted with a 1:1 ratio, since although a higher torque is generated, most of this is transmitted via the annulus gear instead of directly via the drive wheel. It is only during the step-up ratio pretensioning that the drive wheel takes most of the torque.

It will be noted that when pretensioning is done at a 1:1 ratio, all of the chain 4 passes onto the drive wheel 3 because of the high forces exerted by the pretensioner and thus the piston 5 has reached the end of its travel and the pressure is relieved. However in the step-up ratio, the chain 4 may not be fully wound on the drive wheel and some residual pressure may still be incident on the piston 5 and thus on the chain 4 and this will jam the drive wheel in the retracted position. The step-up gear ratios particularly useful for conditions where a low force but a high level of pull-in of the seat belt webbing is required. However the 1:1 ratio would be used where a high force is available and a low pull-in of seat belt webbing is acceptable or even desired. This is likely to be the case in high speed crashes or in occupant out of position situations. Sophisticated sensors are now available to detect particular crash conditions and particular occupant positions and switching could be effected on the basis of these sensed conditions.

The switching is also of course done to bring the comfort device into operation. The comfort device is only required after a certain amount of webbing pay out, since the 1:1 ratio is desirable to ensure that the unbuckled belt "parks itself" satisfactorily, i.e. that the webbing retracts fully (and does not get caught for example in the door when the passenger exits the vehicle).

It is a particularly useful feature of this invention that the same gears can be used for the pretensioning operation and for the comfort device.

The operation of the comfort device will now been described with reference to Figures 3 to 5.

Figure 3 to 5 are cross-sectional views through the pretensioner and gearing system of Figures 1 and 2 and illustrate the operation of the comfort device. In Figures 3 to 5 the step-up gearing is operable, thus the annulus gear 16 is engaged with the housing 2 and is stationary and the planet gears 13 rotate about their axes on respective sub stabs 12 by engagement with the inner teeth 22 of the stationery annulus gear 16. For every single turn of the drive wheel 3, the sun gear 14 rotates 4.33 times.

Figure 3 shows a start position, i.e. zero rotation of the drive wheel and zero rotation of the sun gear (and hence of the retractor spool).

Figure 4 shows the situation after the retraction spring has caused a rotation of 90° of the drive wheel 3. Thus the reference line A on the drive wheel 3 has moved through 90° and thus the stub tab 12^1 carrying planet gear 13^1 has moved from the position at 12 o'clock in Figure 3 to the position at 3 o'clock in Figure 3. During this movement the teeth of planet gear 13^1 engage with the inner teeth 22 of the annulus gear 16 and cause the planet gear to rotate about the stub tab 12^1 in an anti-clockwise direction as viewed in the Figures and the reference line B on the planet gear 13^1 has moved to the position shown in Figure 4. This corresponds to almost a full rotation of planet gear 13^1 about its own axis and this in turn causes just over a full rotation (390° in this case) of the sun gear 14 so that line

C on the sun gear 14 has moved through 390° between Figures 3 and 4.

In Figure 5 the retraction spring has caused the drive wheel rotation of 180° and this results in the sun gear 14 and thus the shaft of the spool rotating 780°. This of course corresponds to more than two full rotations of the sun gear.

Figure 10 is a graph showing rotation force against retraction distance in the operation of the comfort device only for the 1:1 gear ratio in lines 27 and for the step-up gear ratio (4⅓:1) in lines 28. It will be seen that a much lower force is generated using the step-up gear ratio.

The operation of the pretensioner will now be described with reference to Figures 6 to 9. Like parts are denoted by like reference numerals.

In Figure 6 the start position is shown. The high speed, step-hup gearing is engaged since the annulus gear is stationery and is engaged with the housing 2. The chain 4 is located in chain track 25 in housing 2 and is separate from the drive wheel.

In Figure 7 gas has been introduced through gas inlet 6 in the housing 2 exerting a force on piston 5 and pushing chain 4 along the chain track 25 into engagement with the drive wheel 3. The drive wheel 3 thus begins to turn as indicated by the displacement of reference point A on the drive wheel 3. This moves the stub tabs 12 and hence planet

gears 13 turn anti-clockwise as indicated by displacement of the reference lines B in Figure 7 compared to Figure 6. As the chain is driven further out of the chain track 25 it engages more of the drive wheel 3 and drives it further in a clockwise direction, rotating the planet gears further and consequently rotating the sun gear 14 in a ratio of about 1:4.33 in this example. It can be seen that the reference line C on sun gear 14 has moved through 90° between the position of Figure 6 and Figure 7 and through 270° from Figure 6 to Figure 8. This for a rotation of the drive wheel of only about 60°.

In Figure 9 the sun gear 14 has effected a rotation of 720° and the chain is full engaged with the drive wheel. This is for a rotation of the drive wheel 3 of about 167° (less than half a turn) corresponding to a chain movement of 80mm.

CLAIMS

1. A pretensioner for rapidly rewinding seat belt webbing onto a spool of a vehicle safety restraint seat belt retractor, the pretensioner comprising

drive means for rapidly rewinding the retractor spool in response to predetermined conditions indicative of a crash,

a gear system linking the drive means to the retractor spool, the gear system being operable in at least two different ratios, and

switching means for changing the gear system ratio.

2. A pretensioner according to claim 1 wherein the drive means comprises

a drive wheel with radially extending peripheral teeth,

a flexible elongate member with apertures regularly spaced along its length, the spacing corresponding to the spacing of the teeth on the drive wheel, and

means for driving the flexible member, in response to a pretensioning signal, generally tangentially to the drive wheel to engage the teeth and to rotate the drive wheel.

3. A pretensioner according to claim 1 or claim 2 wherein the flexible member comprises an interlink chain.

4. A pretensioner according to any preceding claim wherein the gear system comprises epicyclic gears.

5. A pretensioner according to claim 4 wherein the epicyclic gears comprise planetary gears and are arranged with a gear ratio of 1:3 or higher.

6. A pretensioner according to claim 5 wherein the epicyclic gears are arranged to also exhibit a gear ratio of 1:1.

7. A pretensioner according to claim 6 comprising an annulus gear interposed between the drive wheel and the planetary gears.

8. A pretensioner according to claim 7 wherein the switching means operates to move the annulus gear between a first position in which it is prevented from rotating and a second position in which it rotates with the drive wheel.

9. A pretensioner according to any one of the preceding claims comprising at least one sensor for detecting a predetermined condition of a vehicle occupant, and for generating a signal indicative of the sensed condition to control the switching means for determining the ratio of the gear system.

10. A pretensioner for rapidly rewinding seat belt webbing onto a spool of a vehicle safety restraint seat belt retractor substantially as hereinbefore described with reference to the accompanying figures.

11. A retractor for a vehicle safety restraint system comprising a rotatable spool for storing safety belt webbing, and a pretensioner according to any one of the preceding claims.

12. A retractor according to claim 11 further comprising means for reducing the tension in the safety belt exerted by the retractor rewind spring.

13. A retractor according to claim 11 or 12 wherein the tension reducing means is operable between predetermined extensions of the seat belt webbing.

14. A retractor according to claim 12 or 13 wherein the tension reducing means comprises epicyclic gears.

15. A retractor according to claim 12, 13 or 14 wherein the tension reducing means comprises the gear system linking the pretensioner to the spool shaft.

16. A retractor substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Application No: GB 9713725.1
Claims searched: 1-16

Examiner: J.C. Barnes-Paddock
Date of search: 12 September 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): A3V

Int Cl (Ed.6): B60R 22/44, 46

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2 306 294 A	(TENSATOR) See p. 2, para 1 to p.3, para 1 and Claim 1. An epicyclic two ratio retractor with lockable annulus.	1,4
Y	GB 2 292 304 A	(NSK) See fig. 5. A pretensioner adapted to drive an epicyclic retractor.	1,4
A	WO 97/13661 A1	(ALLIEDSIGNAL) See Fig. 2. A piston and chain driven pretensioner	
A	US 4 301 977	(PACIFIC) See Fig. 5 An epicyclic two tension retractor.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.